Linking Cancer Surveillance and Environmental Data

Radium in Drinking Water and the Incidence of Osteosarcoma

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Purposes of Linking Health and Environmental Data

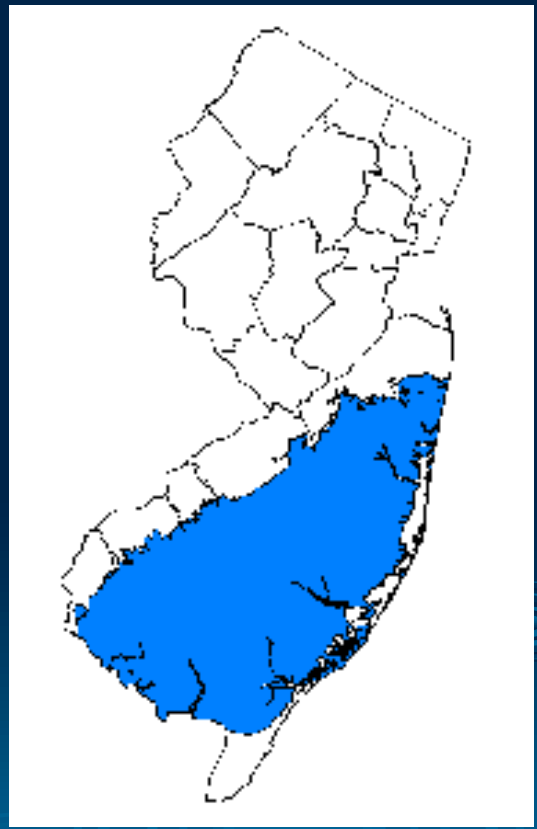
- To understand relationship between environmental hazards and human health
- To provide scientific basis for public health interventions
- To evaluate effectiveness of interventions

Radium

- Naturally-occurring radioactive element
- Generated by the radioactive decay of naturally-occurring uranium and thorium
- Three isotopes with different half-lives:
  - Radium-224 (3.6 days)
  - Radium-226 (1,620 years)
  - Radium-228 (6.7 years)

Radium in New Jersey Groundwater

- Occurs naturally in shallow aquifers of southern and central New Jersey
- Routine testing procedure did not include short-lived isotopes before 1997
- NJDEP and USGS surveys in 1997-2000 include short-lived isotopes



Health Effects of Radium Exposure

- Exposure to high levels of radium causes:
  - Osteosarcoma and other bone cancers
  - Leukemias
- Uncertain health risk at low exposure
- USEPA: lifetime excess cancer risk of 1 to 3 cases per 10,000 exposed, at MCL for radium of 5 pCi/L

Previous Epidemiologic Studies

- **Iowa/Illinois** (1966)
  - Increased bone cancer mortality
- **Ontario** (1994, 1996)
  - Increased osteosarcoma in males
- **Wisconsin** (1995, 2002)
  - I: Increased risk of osteosarcoma in females
  - II: No increased risk

Osteosarcoma

- Rare cancer of the bone
  - 3 persons per million each year
  - Peaks in adolescence and > 50 yrs
- Known risk factors:
  - Radium and radiotherapy
  - Certain chemotherapeutic agents
  - Certain genetic syndromes affecting bone growth

Study Questions

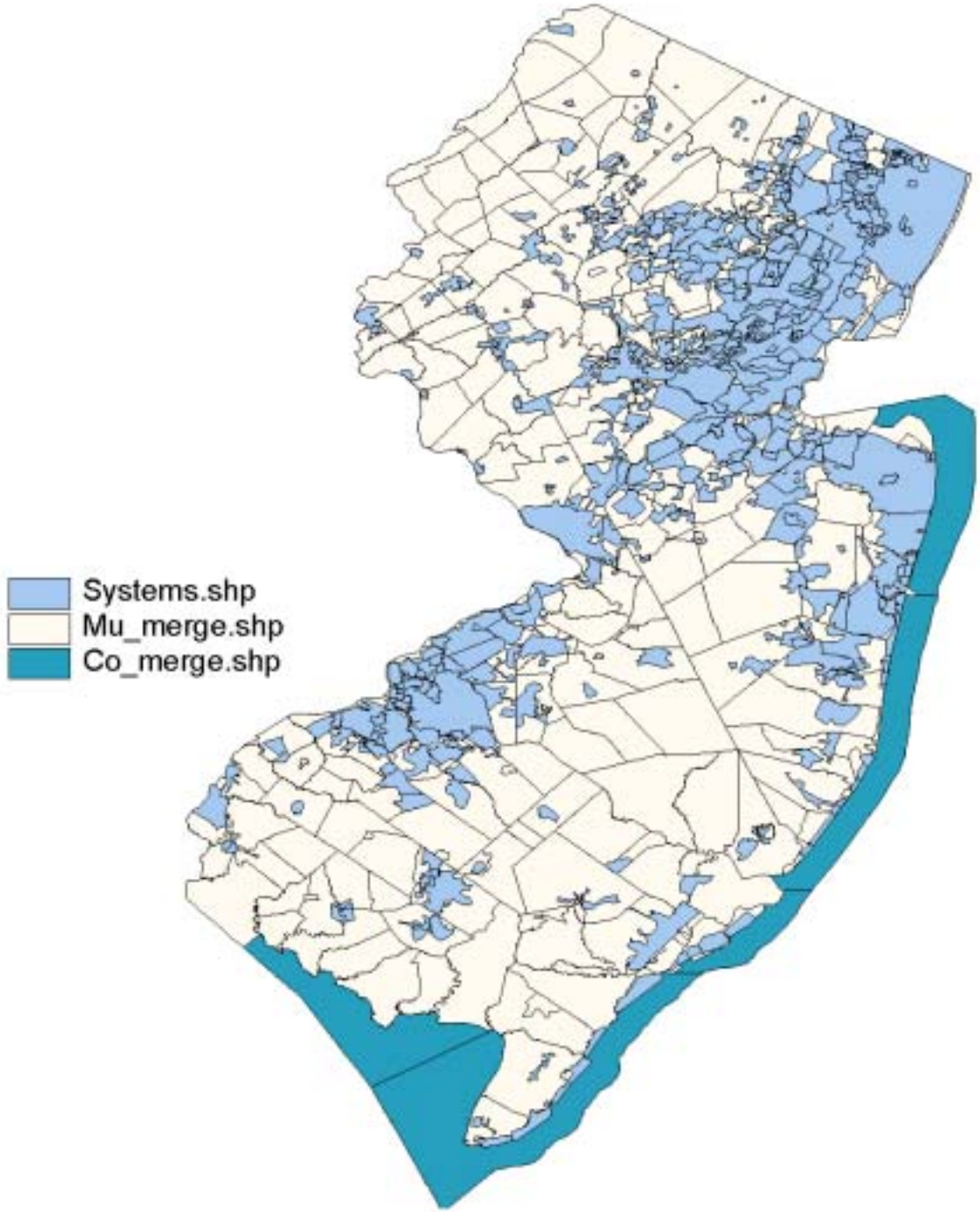
- Understanding exposure-disease:
  - Is the incidence of osteosarcoma higher in areas with elevated levels of radium in drinking water?
- Scientific basis of MCL:
  - Is USEPA's risk assessment accurate?
  - Is MCL as protective as intended?

Study Design

- Map water systems and characterize exposure levels
- Compute populations exposed based on overlay of water system and census tract boundaries
- Assign cases (1979-1998) to water systems based on address at diagnosis
- Compare osteosarcoma incidence rates, among populations with different levels of radium in drinking water

System Areas in the Study

- All community water supplies in southern and central New Jersey, except:
  - insufficient data
  - major, recent changes in well use
  - use of surface water
  - service in shore areas
  - added fluoride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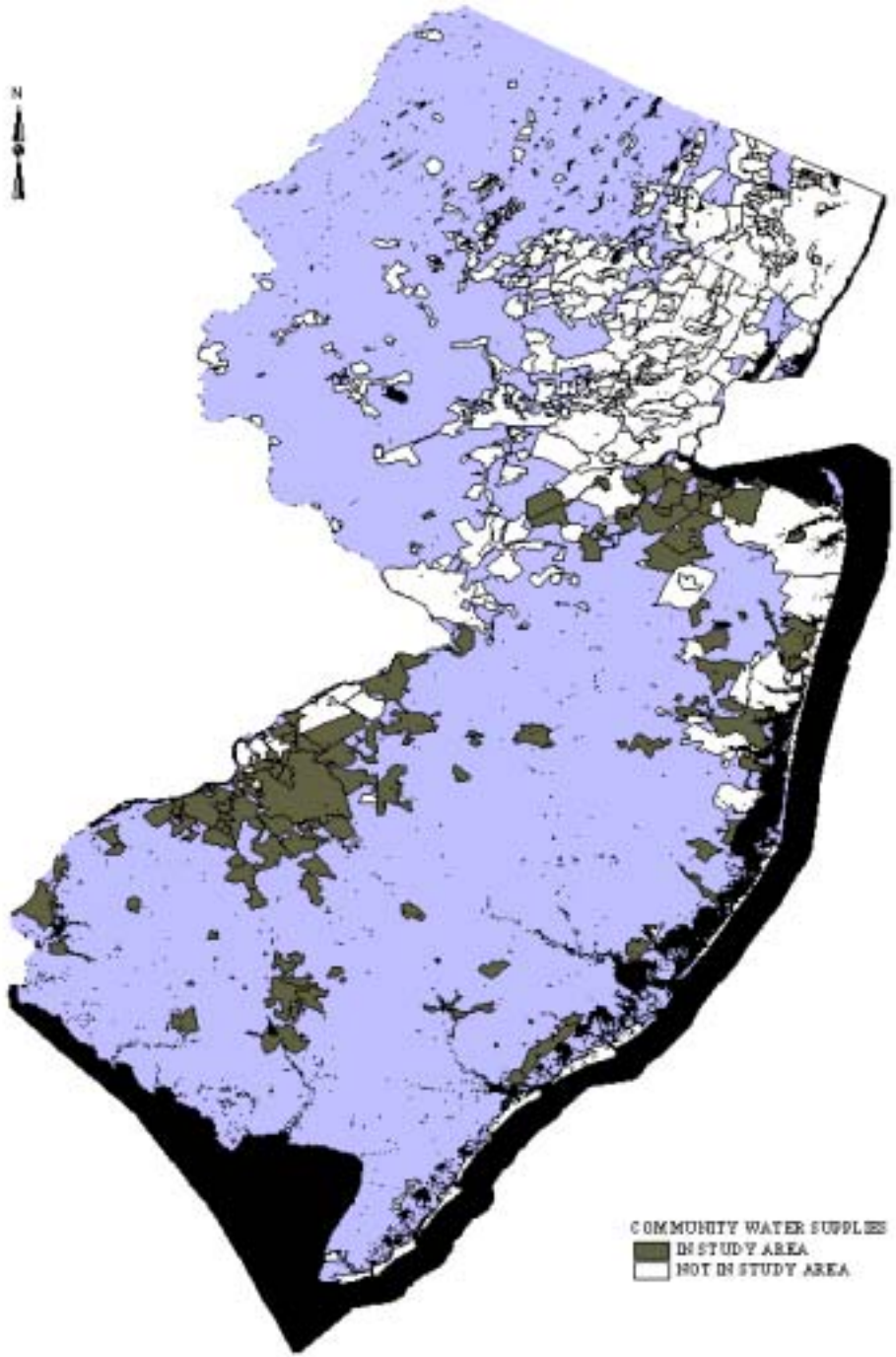

N
COMMUNITY WATER SUPPLIES
IN STUDY AREA
NOT IN STUDY AREA

Systems Grouped Using Two Exposure Measures

- Greater or less than either gross alpha or radium MCLs
- Radium-228 potency equivalent level (pCi/L), based on amounts and cancer-causing potencies of three radium isotopes

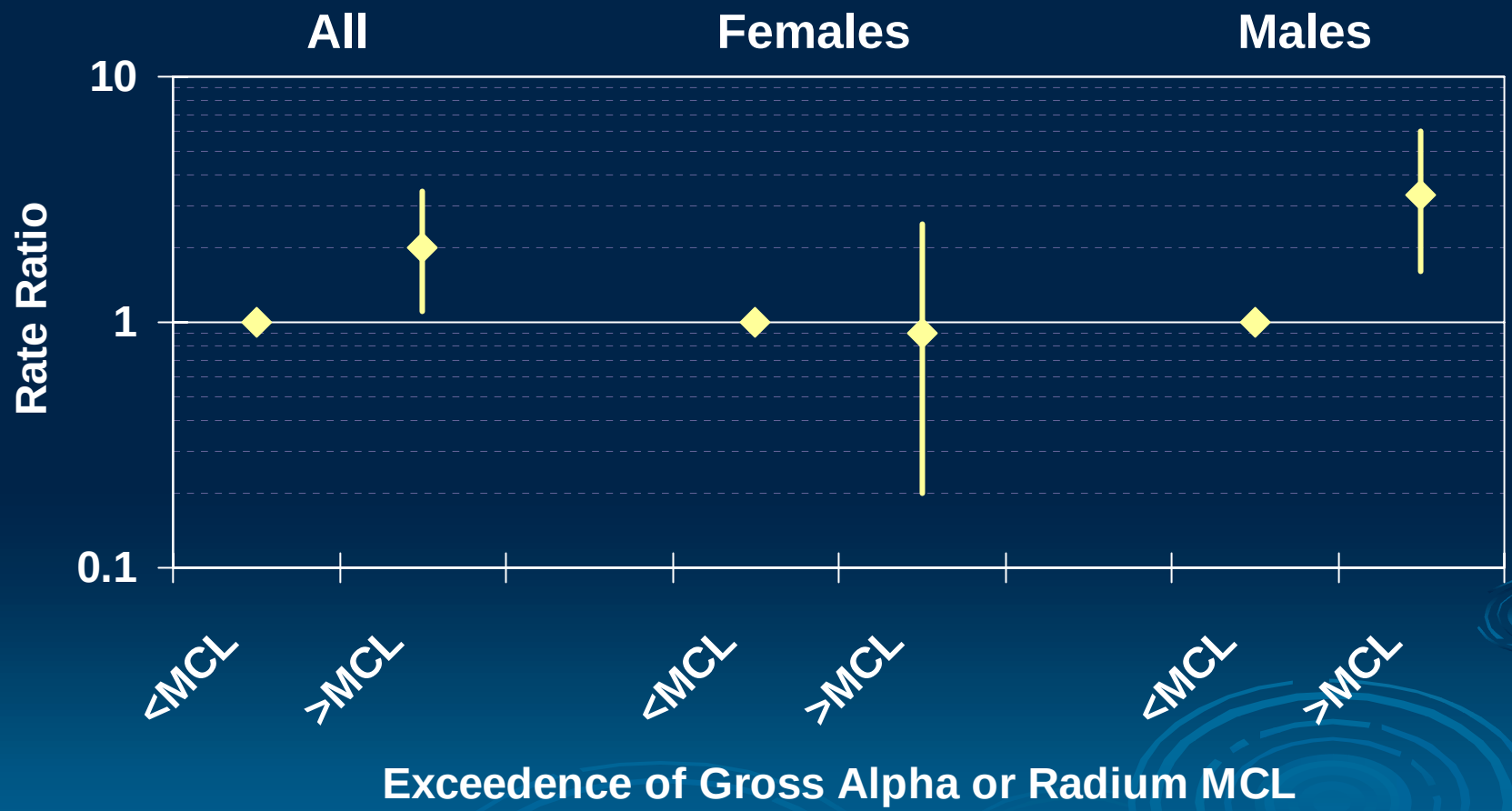
Systems and Populations by Exposure Group

Exposure Group	# Systems/ Subsystems	Total Population
Gross alpha and radium MCLs		
< MCLs	100	1,287,336
≥ either MCL	17	135,638
Radium-228 potency equivalents, pCi/L		
≤0.5	76	979,001
0.5-1.9	14	168,229
2.0-3.9	12	147,272
≥4.0	15	128,472

Study Cases, 1979-1998

Age	Males	Females
0-9	0	1
10-24	21	15
25-49	4	6
50+	14	14
Total	**39**	**36**

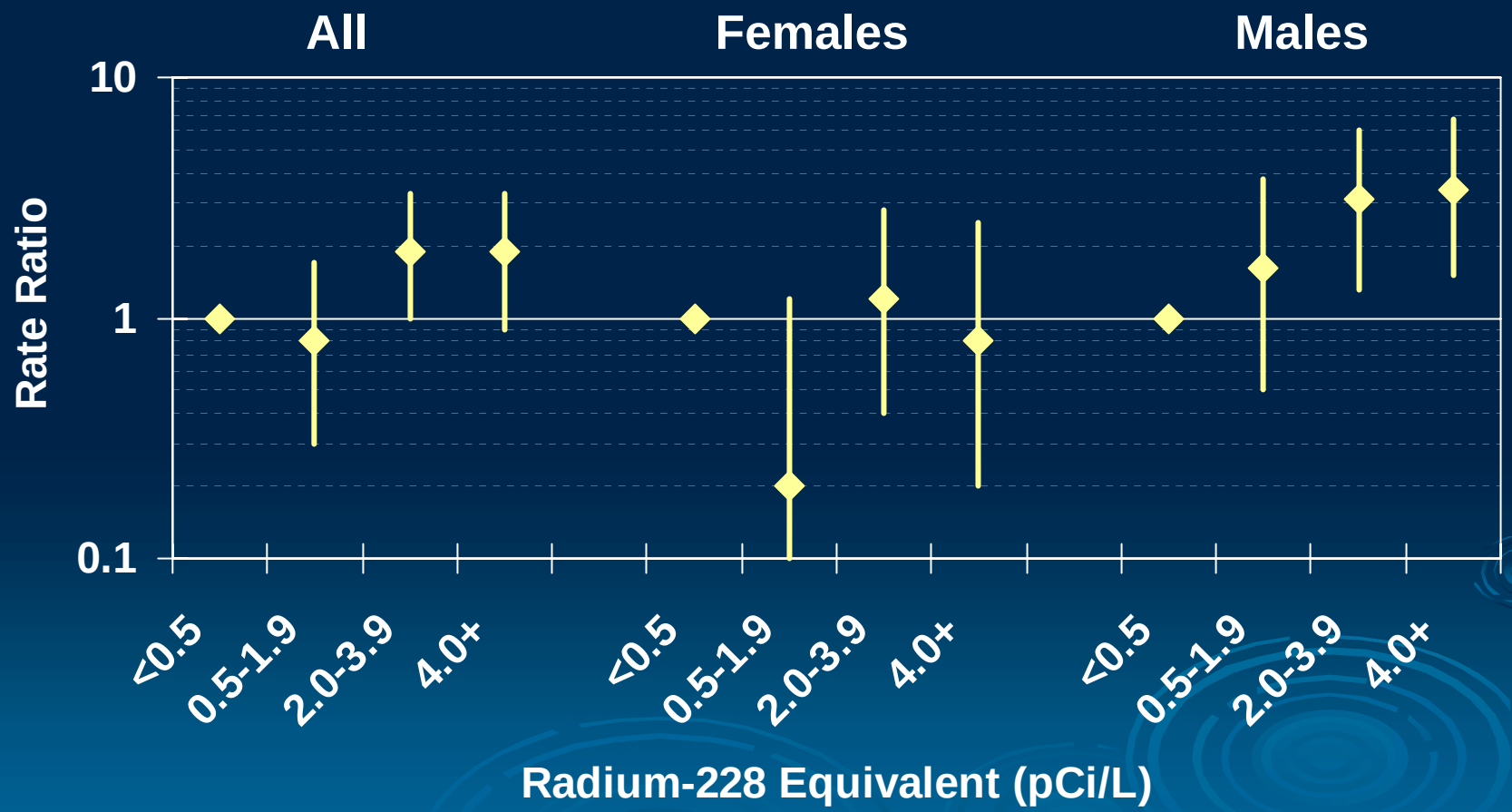
Incidence Rate Ratios Relative to MCLs



Incidence Rate Ratios Relative to MCLs

	Exposure	Pop	N	Annual Rate Per Million	Rate Ratio (95% CI)
All	<MCL ≥MCL	1,287,336 135,638	62 13	2.4 4.8	1.0 **2.0 (1.1, 3.4)**
All Males	<MCL ≥MCL	617,223 65,257	29 10	2.3 7.7	1.0 **3.3 (1.6, 6.0)**
All Females	<MCL ≥MCL	670,113 70,381	33 3	2.5 2.1	1.0 0.9 (0.2, 2.5)

Incidence Rate Ratios By Ra-228 Equivalent Levels



Incidence Rate Ratios By Ra-228 Equivalent Levels

	Ra-228 Equivalent (pCi/L)	Pop	N	Annual Rate Per Million	Rate Ratio (95% CI)
All	< 0.5	979,001	45	2.3	1.0
	0.5-1.9	168,229	6	1.8	0.8 (0.3, 1.7)
	2.0-3.9	147,272	13	4.4	**1.9 (1.0, 3.3)**
	≥ 4.0	128,472	11	4.3	1.9 (0.9, 3.3)
All Males	< 0.5	471,462	18	1.9	1.0
	0.5-1.9	80,907	5	3.1	1.6 (0.5, 3.8)
	2.0-3.9	68,213	8	5.9	**3.1 (1.3, 6.0)**
	≥ 4.0	61,898	8	6.5	**3.4 (1.5, 6.7)**
All Females	< 0.5	507,539	27	2.7	1.0
	0.5-1.9	87,322	1	0.6	0.2 (0.0, 1.2)
	2.0-3.9	79,059	5	3.2	1.2 (0.4, 2.8)
	≥ 4.0	66,574	3	2.3	0.8 (0.2, 2.5)

Lifetime Excess Cancer Risk

Data Source	Exposure Level	LECR per 10,000
USEPA (2000) Risk Assessment	5 pCi/L radium MCL	1.0 to 2.9
Iowa/Illinois (1966)	≥ 3 pCi/L radium-226	1.9
Ontario (1994, 1996)	≥ 0.8 pCi/L	1.3
Wisconsin (1995)	≥ 9 pCi/L	0.7
Wisconsin (2002)	> 5 pCi/L	No increase
New Jersey (2003)	> MCL ≥ 2 pCi/L radium-228 eq.	1.7 1.5

Conclusions

- Linking health surveillance and monitoring data enables us to:
  - Show association between radium in drinking water and increased rate of osteosarcoma in males but not females
  - Confirm the USEPA health risk assessment based on highly exposed occupational and medically-exposed cohorts

Implications for Practice

- Testing procedures now include short-lived radium-224
- Water supplies are assessing compliance with MCLs and installing treatment systems as needed
- Private well testing mandates are identifying wells of concern
  - Radium is easily removed by properly maintained water softeners